Shaking things up:
Can full-body games become more accessible?

Dimitris Grammenos
ICS-FORTH
gramenos@ics.forth.gr

Introduction

It is quite some time since the entrance of Microsoft's Kinect and its full-body gaming approach in our lives. During its launch there has been a vivid discourse regarding emerging game accessibility problems that it was about to introduce to gamers. Unfortunately, it seems that nowadays the fuss has settled down. One cannot say for sure if this is because people lost their interest, or hope (or maybe both). Up to now, there just have been a handful of Kinect games[1] which can be played while seated, and thus are (potentially) accessible to people in wheelchairs that have full control of their upper body. But there is a much wider range of people "with" (e.g., amputees, people with arthritis) or "without" disabilities (e.g., you might as well just be tired) for which Kinect games can be hard, or even impossible to play.

At a time where a new paradigm shift in game control (bringing about its own accessibility problems) is already underway through two-screen game control approaches such as Nintendo Wii U, Xbox SmartGlass and PS Vita, this article aims to shake things up a little, hoping to respark public discourse, as well as the generation and critique of novel ideas and approaches towards achieving universally accessible[2] full-body games.

At this point, it should be pointed out, that in this article the term "(video) game accessibility" is used to describe a situation in which a person is able to play a game even whilst having "diversified needs", or whilst playing under "limiting conditions", irrespectively of whether any of these are attributed to, permanent or temporary, physical, sensory or mental disabilities.

First things, first…

By the end of 2011, at the Institute of Computer Science of the Foundation for Research & Technology – Hellas (ICS-FORTH) we were working towards developing an advergame installation targeted to promoting, in exhibition spaces and key points of sale, the products of a food company producing various types of traditional Cretan rusks. The game, entitled "Paximadaki" (*small rusk* in Greek) is a Kinect-based PC *exergame*, involving physical activity. The main reason for selecting Kinect was that it allows for non-instrumented game control through natural movements. In this respect, it was decided to just use the depth camera's image in order to render a virtual shadow of the players, instead of tracking their body

[1] http://support.xbox.com/en-US/kinect/body-tracking/accessibility-kinect

[2] Grammenos, D., Savidis, A. and Stephanidis, C. (2009) Designing universally accessible games. Comput.Entertain., 7(1), 1-29.

skeletons. Our rationale was two-fold. On the one hand, it was assumed that it would be easier for people, especially “non game-players”, to identify with their shadow rather than with an avatar, thus achieving a higher level of control and immersion. On the other hand, this approach allowed for maximum flexibility regarding the number, posture and size of players, as well instantly joining and leaving the game, thus maximizing the opportunities for social interaction. The downside was that people with larger body sizes had a clear advantage, and that there was the possibility of accidental “intrusions” in the play area.

Figure 1. Paximadaki, the game: Screenshot of indicative gameplay

The gameplay[3] is quite simple and straightforward, with clear goals. Players perceive their bodies as shadows projected on a brick wall (Figures 1, 2 & 3). Depending on the players’ number, there may be one or two baskets at the two bottom sides of the wall. A ‘rainfall’ of rusks starts. Players must use their shadows to put the rusks into their basket. Rusks that fall on the floor are broken into pieces. The game ends when a certain number of rusks have fallen.

[3] Videos of indicative play sessions can be found at: http://www.youtube.com/user/icsforthami

Figure 2. Paximadaki, the game: Playing a two-player competitive game

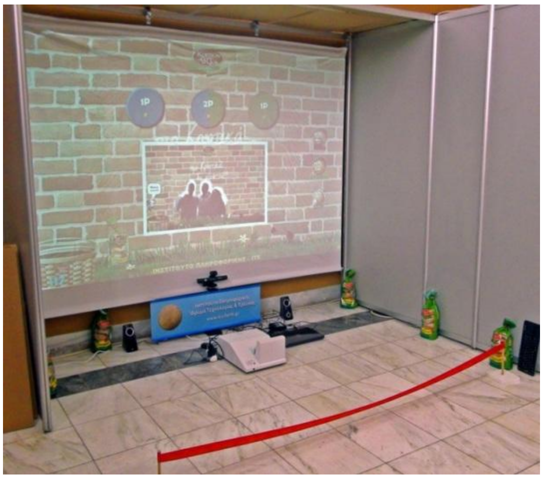

Figure 3. Paximadaki, the game: Indicative game setup

Following a practice that in the past[4] proved to considerably aid towards supporting easy gameplay adaptation, software maintenance, and universal access, all game assets and the gameplay for each distinct level, are defined through a set of rules residing in external files. This way, one can easily experiment with and fine-tune all game factors that may aid towards making the game appropriate for a particular group, or even, an individual person.

Taking accessibility into account

The notion of whole-body play (though at a more rudimentary level) has been around since Myron Krueger's artificial reality work starting back in 1969. In the beginning of our century it has been popularized by Sony's EyeToy and more recently revolutionized by Kinect. But, unfortunately, there is very limited (if any) design wisdom regarding whole-body games' accessibility. Thus, while designing and developing "Paximadaki", we attempted to envision - and whenever possible experiment with – alternative ways of making it accessible, mainly to people with motor impairments and to the blind, as well as people in equivalent situations which may not be related to physical disabilities, since these are the cases in which the game is particularly hard or even impossible to play. This article focuses on alternative solutions (see Table 1 for an overview) targeted to people with motor impairments, which can be classified in two categories[5]:

a. "Kinect-less" gaming

This is the rather obvious category, and thus is the one which has already been mentioned in the past[6]. Instead of using Kinect, the player employs an alternative, more suitable, controller (joypad, keyboard, mouse, switches, etc.) to play the game (Figure 4). Of course,

[4] Grammenos, D. 2008. Game over: learning by dying. In Proceeding of the Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems (Florence, Italy, April 05 - 10, 2008). CHI '08. ACM, New York, NY, 1443-1452. DOI= http://doi.acm.org/10.1145/1357054.1357281

[5] Note: Depending on the player's abilities additional gameplay adaptations may be required, such as changing the speed / size of the falling objects, how far from the player they appear, the number of concurrently falling objects, the size / position of the basket, etc.

[6] http://www.gamebase.info/magazine/read/kinect-accessibility-round-table_342.html

in this case, the player does not perceive his own shadow on the wall as originally designed, but an avatar. Depending on the sophistication of the approach, this avatar may be:

1. a static image that the player can just move left/right;
2. a more accurately modeled virtual body, parts of which (e.g., hands/head posture) may be individually controlled by the player, with our without the help of the game's AI.

Pros:

- (Quite) easy to implement.
- Eliminates the need of having a Kinect.
- Can be played in limited space - even on a laptop.
- In combination with a Kinect, allows players with very different abilities to play against one another in the same environment.
- Eliminates the need for body movement.

Cons:

- The player does not perceive his own image in the game (to compensate for this the avatar can be personalized – see Figure 4).
- The game becomes more "ordinary".
- Eliminates any player body movement (beyond controller use), even if the player is able to perform some, thus reducing the amount of physical exercise supported.

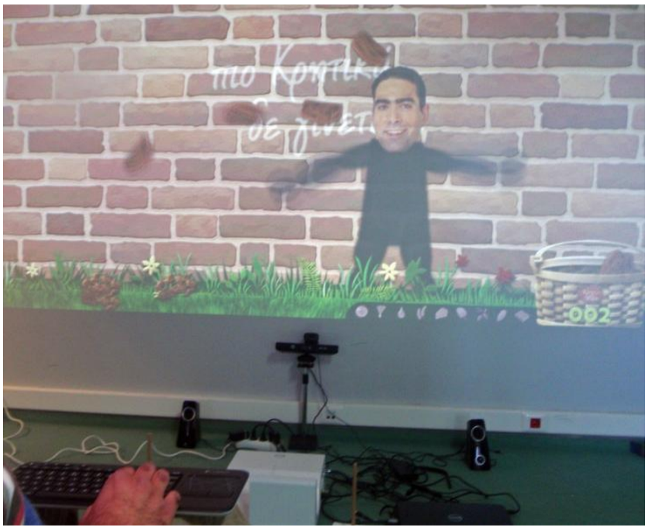

Figure 4. Kinect-less game: The player uses left/right arrows to move the avatar's torso and up/down to raise/lower its arms. When the avatar is moving, its head automatically leans to the opposite direction. Alternatively the avatar can be controlled using a single switch (auto-move, change direction movement / stop moving, hands change posture depending on movement), or even using up to 6 keys/switches (left/right + separate control for each arm).

b. Kinect-based gaming

This category comprises several alternative approaches which share the fact that Kinect is used to fully, or partially, control the game – even if not as it was originally envisioned.

b.1. Hand puppet / Marionette control

Up to now, Kinect has been used to control virtual puppets[7]. There is no reason why things could not also work the other way around. Instead of tracking the player's body shape, Kinect is directed towards a hand puppet, or a marionette, controlled by the player (see Figure 5). A *hand* (or glove) *puppet* is controlled by one hand which occupies the interior of the puppet. The "puppeteer" can mainly control the puppet's head and arms position. A *marionette* (or string puppet) is suspended and controlled by a number of strings, attached to a bar held from above. Depending on the number of strings, the player can control the head, arms and legs of the puppet. Although when following this approach the player still does not perceive his own image in the game, some of "Kinect's magic" is retained, since a physical body in the real world affects virtual objects in the game world. Additionally, judging from our own experience, this way of playing - letting the accessibility dimension aside - is quite fun, especially in multiplayer games! Furthermore, *w*ith some additional tweaking, body tracking algorithms could successfully extract human body skeleton models from hand or string puppets, thus enabling more accessible Kinect games in general.

Pros:

- There is no need for any additional coding.
- Supports a certain level of physical activity.
- Retains the mixed-reality approach of the original game.
- Game control is very intuitive.

Cons:

- The player does not perceive his own image in the game.
- Requires the ability to move one hand – especially the Marionette requires considerable manipulative control.
- May tire some players.

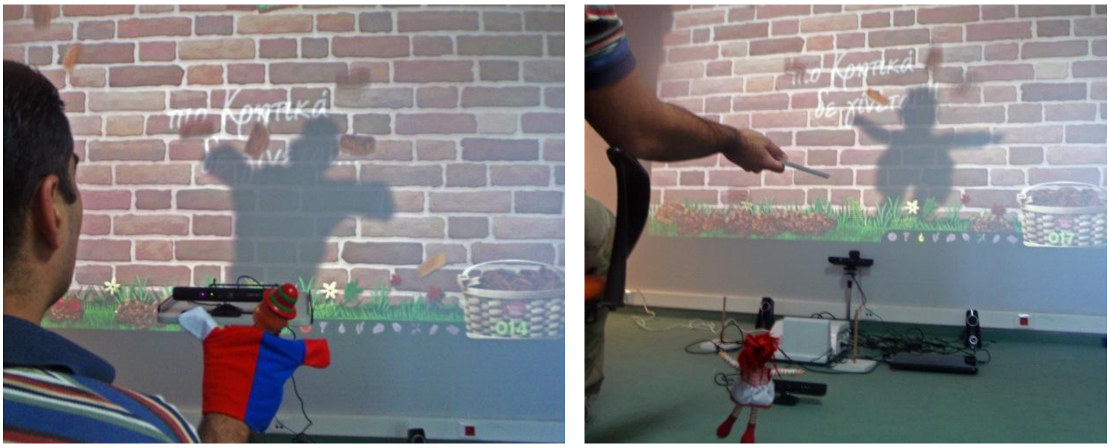

Figure 5. Using a hand puppet (left) and a (simple) marionette (right) to play the game.
The player's body is masked based on its distance from Kinect.

[7] http://vimeo.com/16985224

b.2. Mapping player's hand to an avatar

This approach is actually a variation of the one mentioned above, but without the use of a puppet. The player uses his hand as if inside the glove of hand puppet. Subsequently, modeling software maps the player's hand to a virtual puppet and projects the result in the game world (see concept photo in Figure 6).

Pros:

- Minimal body movement required (less than in the puppet approach).
- Less restrictive than the puppet approach –no need for any props or training in how to use.
- Retains the mixed-reality approach of the original game.
- Game control is very intuitive.

Cons:

- The player does not perceive his own image in the game.
- Requires the ability to move one hand.
- May tire some players.
- Code required for hand tracking, modeling and mapping it to the avatar.

Figure 6. Mapping a player's hand to an in-game avatar
(*concept photo – not currently implemented*)

b.3. Kinect input + alternative controllers

Here, an attempt is made to combine the best of both worlds. On the one hand, Kinect is used to capture the player's body shape, so that he can identify with his in-game image, while, on the other hand, alternative controllers are used to compensate for any player's movement restrictions (see Figure 7). For example, a seated person may use his upper body (including his arms if possible) to knock rusks into the basket, while employing switches / head tracking / speech recognition / etc. to move his projected shadow (e.g., left / right) in the game world.

Pros:

- The player perceives his own image in the game.
- Retains the mixed-reality approach of the original game.
- Supports a certain level of physical activity.

- Can accommodate a large range of motor disabilities (even one-switch game can be supported).

Cons:

- Additional hardware setup or coding will be required.
- Control is less intuitive and direct for novice video game players than in the Kinect-only game.
- May tire some players.

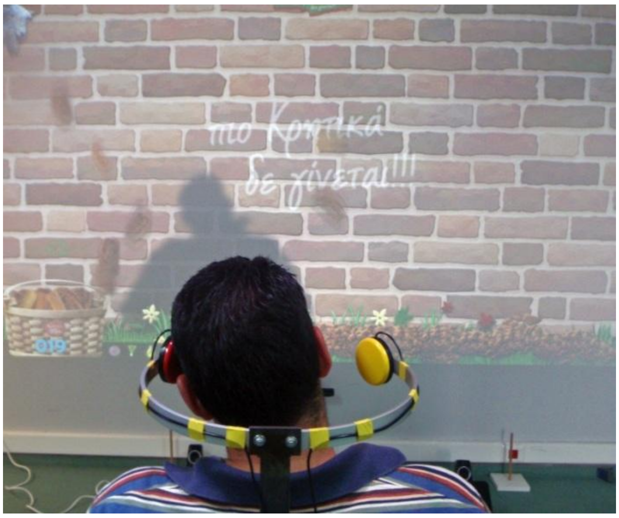

Figure 7. Kinect is used to project the player's body in the game world, while two switches are used to move the player's shadow left/right when his head leans correspondingly. The same result can be achieved through various ways including head tracking, any type of switches (foot, sip-n-puff, tongue), speech recognition, etc.

b.3. The 'Frankenstein' approach[8]

A virtual image of the player is assembled using the (real) tracked body parts of one or multiple players or even AI. For example, one player moves the hands, another player moves the legs and finally the game AI moves the head. Another example is to re-map a single player's limbs, e.g., use the left leg for moving left and the left arm for moving right. Such an approach can potentially make all Kinect games accessible, as well as introduce a novel paradigm for social game-playing.

Pros:

- Eliminates need for additional controllers.
- Can accommodate players with a very large range of disabilities.
- It retains the way Kinect is typically used.
- Encourages and supports social gaming.

Cons:

- The player does not perceive his own image in the game.
- Requires additional people to play.
- Additional coding for hand tracking, modeling and "assembling" the various body parts.

[8] Grammenos, D. (2010). Universally Accessible Games & Parallel Game Universes, I International Conference on Translation and Accessibility in Video Games and Virtual Worlds, 2 and 3 December 2010, Universitat Autonoma de Barcelona, Spain. http://www.ics.forth.gr/hci/ua-games/docs/DGrammenos_Universally_Accessible_Games_and_Parallel_Game_Universes.pdf

	Solution	Pros	Cons
Kinect-less	Alternative controller (joystick, keyboard, mouse, switches, etc.) + player avatar (simple or sophisticated)	• (Quite) easy to implement • No need for having a Kinect • Can be played in limited space • In combination with a Kinect allows players with very different abilities to co-play • Eliminates the need for significant body movement	• Player does not perceive his own image in the game • "Ordinary" computer game • Totally eliminates player body movement (beyond controller use) / reduces amount of physical exercise supported
Kinect-based	Hand puppet / Marionette control	• No code needed • Supports a certain level of physical activity • Retains the mixed-reality approach of the original game • Intuitive game control	• Player does not perceive own image • Requires ability to move one hand • (Marionette) requires considerable manipulative control • May tire some players
	Mapping player's hand to an avatar	• Minimal body movement required (less than the puppet approach) • Less restrictive - no need for props or training • Retains the mixed-reality approach of the original game • Intuitive game control	• Player does not perceive own image • Requires ability to move one hand • May tire some players • Code for hand tracking, modeling and mapping the hand model to the avatar required
	Kinect input + alternative controllers	• Player perceives own image • Retains the mixed-reality approach of the original game • Supports a certain level of physical activity • Can accommodate a large range of motor disabilities (even 1-switch games)	• Additional hardware setup or code required • Less intuitive and direct for novice video game players • May tire some players
	Frankenstein: tracking body parts from multiple players and mapping them to avatar	• Eliminates need for additional controllers. • Can accommodate a very large range of disabilities. • Retains the way Kinect is typically used. • Encourages and supports social gaming.	• Player does not perceive own image • Requires additional people to play • Code for hand tracking, modeling and "assembling" body parts

Table 1. Overview of alternative accessibility solutions discussed

What about multiplayer games?

Following the concept of Parallel Game Universes[9], one or more of the approaches described above can be combined in order to support multiplayer games among people with varying abilities. For example, a player's shadow tracked using Kinect, can easily "co-exist" with the avatar of another player, manipulated trough any type of controller (Figure 8 - left). Additionally, in case of competitive gaming one could create different types of rusks targeted (i.e., can be hit) by each player, the characteristics of which are adapted to the player's capabilities. Multiplayer gaming can also be made possible even if both players are using a Kinect-based approach (e.g., one of them is using just Kinect, while the other *Kinect input + alternative controllers*). For example, one idea is to have the non-seated player moving behind the seated-one, and "split" Kinect input in two independent streams of data, based on player distance (Figure 8 – right). Of course, there might be some accidental "dismemberments" when players' body parts accidentally (or intentionally) cross the borderline, but this may also be exploited as an exciting game feature.

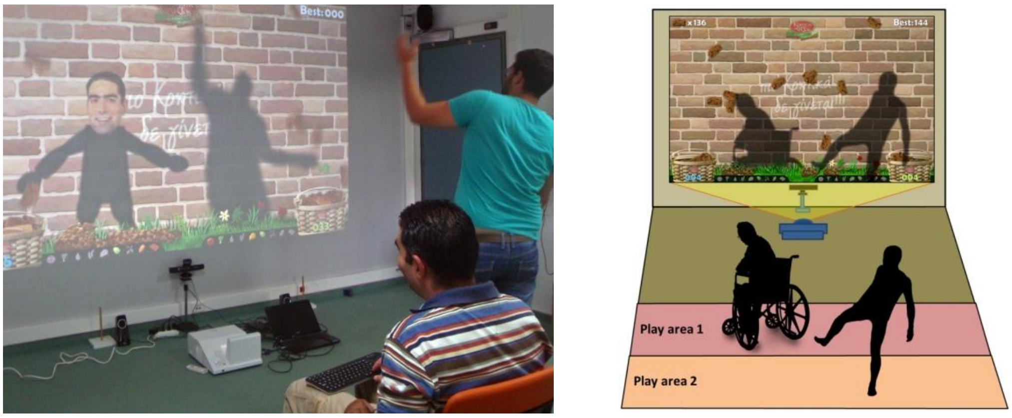

Figure 8. Multiplayer games following the Parallel Game Universes approach: (left) one player uses Kinect and the other a keyboard-controlled avatar; (right) both players use Kinect, but one of them in combination with two switches (for left/right movement)

Benefits for all

Beyond the obvious (and less obvious[10,11]) reasons, for which one might want to consider including accessibility features such as the ones described in this article in a game, there are several additional benefits that the aforementioned approaches can offer, such as:

1. Support for easy, efficient and sweat-free game debugging and testing. Having to stand up and move every time you change a couple of lines of code or a parameter value in your game takes a lot of time and energy. A mouse / keyboard driven-avatar is a very handy tool, also allowing to test your game even when you don't have a Kinect nearby.

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[9] Grammenos, D. (2006). The Theory of Parallel Game Universes: A Paradigm Shift in Multiplayer Gaming and Game Accessibility. Gamasutra Feature article, August 17, 2006. Available on-line at: http://www.gamasutra.com/features/20060817/grammenos_01.shtml

[10] Grammenos, D. (2007). Game Accessibility - Why Bother? Gamasutra Opinion article, April 24, 2007. Available on-line at: http://www.gamasutra.com/php-bin/news_index.php?story=13650

[11] Grammenos, D., (2012). From Game Accessibility to Universally Accessible Games. To appear in: Mangiron, C.; O'Hagan, M; Orero, P. (Eds.), Fun for All: Translation and Accessibility Practices in Video Games and Virtual Worlds.

Of course, the game should also be tested using the "real" things, as there are significant functional and experience differences among the two approaches.

2. It allows people who may just be tired, do not own a Kinect, or are situated in an environment with not enough space or movement freedom, to play the game.

But most importantly,

3. It can be very fun and exciting. For example, playing the game using the various types of puppets is a very enjoyable experience, for its own sake. Supporting alternative playing styles and approaches allows reaching a much broader audience, and also greatly improves the game's re-playability value.

Afterword

First of all, we have to note here that Paximadaki is not a typical Kinect game, since it does not employ body tracking techniques. Then again, it is still a full-body Kinect-based game. In any case, the goal of this article is not to claim that the presented ideas constitute the definitive approaches towards Kinect/full-body games accessibility, nor to provide a cookbook of ready-made solutions. On the contrary, it is merely a first stepping stone, offering suggestions stemming from the amalgamation of our previous experience in the field of game accessibility with our latest game development efforts, in the hope that it will motivate more creative minds to (metaphorically and literally) come into play along with additional, and eventually better, ideas. After all, it does not take extraordinary technologies to create extraordinary games, just extraordinary thinking!

Probably the biggest mistake of most game development companies up to now is that they try hard to sell *more games* to the *same people*, instead of trying to find ways of selling the *same games* to *more people*. In this regard, one should keep in mind that Kinect is just a means – not the reason – for playing games. What people really want is to have fun, irrespectively of the way this is achieved. Chinese food was originally meant to be eaten with chopsticks. Nevertheless, there are hundreds thousands of people around the world who have no clue of how to use them (or just prefer a fork), and still enjoy this kind of food very much…

Acknowledgments

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